LIGHTING: REDUCING COSTS AND ENERGY USE

You can't see energy – but you *can* see one of the main uses of energy in buildings – lighting. Because lighting can be responsible for 20 to 40 percent of the energy bill, it offers considerable potential for savings. It does not require much technical sophistication to detect problems and to estimate the probable savings. A visual inspection will often reveal that less illumination would be adequate. A more accurate method would be to use a light meter to measure the light levels on any task or area. Many electrical utilities have light meters available for their customers to use.

LIGHTING STANDARDS

Many lights in use today were installed during the days of so called cheap energy, and it was not uncommon for the designers to provide more light than necessary. As a result, excess wattage became part of the system. In recent years, improved lighting standards or guidelines have been developed by the Illuminating Engineering Society, the recognized authority for the lighting industry. These standards allow both the designers and the users of the system to choose the proper level of lighting for any specific commercial or industrial application. Typical values are shown in Table 1.

TABLE 1
Representative Illumination Levels

Area or Activity	Recommended Decalux
Auditoriums	40
Conference rooms	40
Offices	30-75[a]
Fire halls	30
Jail cells	30
Libraries	
Stacks	30
Reading rooms	50
Washrooms	15
Machine shops (rough work)	30[b]
Storage rooms	
Inactive	8
Active	15-30[c]
Swimming pools (exhibition)	50
Arenas	
Amateur sports	50
Professional sports	100

[a] Higher levels for fine work such as drafting.

[b] Much higher levels are required for fine bench or machine work.

[c] Higher levels for small items.

Source: Illuminating Engineering Society, Lighting Handbook, *1981*

EFFICIENCY OF LIGHT SOURCES

Coupled with these new standards has been the improvement of the various types of lamps and light fixtures. There is a wide range of products available to meet the needs of all lighting applications. One of the results of improvements in the design of lamps has been better efficiencies. The efficiency (or efficacy) of a light source is measured in lumens per watt. The lumen is the unit used to measure the light emitted by the lamp, and the watts measure the electrical power required to operate the lamp. Table 2 shows the efficiencies for the most common types of lamps. It can be seen that there is a wide difference in efficiency between the everyday incandescent lamp and the low-pressure sodium type.

TABLE 2
Comparative Efficiencies for Various Light Sources

Type of lamp	Lumens per watt[a]
Incandescent	11-24
Fluorescent	43-85[b]
Mercury vapour	31-59
Metal-halide	81-106
High-pressure sodium	48-128
Low-pressure sodium	56-183

[a] The higher end of the various ranges apply to the higher wattage lamps.

e.g. – 175-watt metal halide – 81 lumens per watt
1000-watt metal halide – 106 lumens per watt.

[b] Assumes the use of standard ballasts. Higher efficiencies are obtainable with various types of energy-efficient ballasts.

As an example of the comparison, a 250-watt high pressure sodium lamp produces approximately the same amount of light as a 1000-watt incandescent lamp but uses only 30 per cent as much energy.

BETTER LIGHTING FOR THE GAME

In 1983 the city of North York began an extensive upgrading of the lighting in its numerous parks and recreational facilities. The following are two examples of the improvements made.

BOND PARK BASEBALL DIAMOND

This park is in use for about 200 hours of darkness during the summer. The original lighting consisted of 110 quartz incandescent lamps each rated at 1500 watts. The baseball players wanted more light, and the operators of the park wanted a system that would require less upkeep. In April of 1985 the existing lighting was replaced with 36 metal-halide lamps, each rated at 1000 watts, mounted in larger reflectors. The total cost of the renovation was $12,132. An annual saving of over $1,000 on the five-month energy bill does not tell the whole story. The new system gives the playing field 30 per cent more light, and the new lamps last several times longer than the old ones. The reaction from the ball players themselves has been very favourable. (Perhaps the umpires' vision is better now?)

CUMMER ARENA AND FITNESS CENTRE

This complex, built in 1979, consists of an arena and a fitness facility that contains a swimming pool, squash courts, and other facilities that are intended for heart and stroke patients. In the summer of 1984, 72 mercury-vapour lamps in the arena, each 400 watts, were replaced with 34 high-pressure sodium lamps of the same wattage. The high-pressure sodium lamps produce more than twice as much light per watt as the mercury-vapour lamps, so fewer are required. The cost of the new system was $11,872. Since the facility is in operation for over 4,500 hours a year, the reduction in lighting load means an estimated energy saving of approximately $3,300. This yields a payback of 3.6 years.

COLOUR OF LIGHTING

It should be noted that not all light sources are suited to every task. We also need to consider a factor known as the Colour Rendering Index (CRI). In simple terms this is a general expression for the effect of the light source on the apparent colour appearance of various objects. All lamps are rated with a CRI number from 0 to 100 with 100 being the best. Incandescent lamps and certain types of fluorescent lamps are generally defined as having the best CRIs, but they are also the least efficient. At the other end of the scale we have high-pressure sodium lamps with relatively poor CRIs and low-pressure sodium lamps, which emit monochromatic yellow light and are usually defined as having zero CRI. The fluorescent family of lamps contains a range of types such as cool-white, warm-white and daylight. The different types are made possible by applying various phosphors to the inside surface of the tube. If colour is not a consideration, one would select the most efficient lamp type. For example, low-pressure sodium lights are well suited to roadways, or parking areas but would be totally unsuited to an office or store.

COLOUR OF LIGHT ENHANCES RETAIL SALES

The Bay Company operates a large department store in the Scarborough Town Centre. Lighting for the retail sales area of about 9,300 square metres (100,000 square feet), consisted of four-lamp fixtures using standard 40-watt warm-white fluorescent lamps. The lighting level was more than adequate, but colour rendition could have been better. A representative from Philips discussed the colour problem with Fred Bergman, Manager of Energy Conservation for the Bay and Simpsons, and suggested a newer type of fluorescent lamp, the Ultralume, which gives much better colour rendition and in addition gives about 8 per cent more light for the same power input. The Bay subsequently removed the four old lamps from about 700 fixtures and installed two of the new Ultralume lamps in each fixture. Mr. Bergman reports that results have been satisfactory.

ENERGY-SAVING OPPORTUNITIES

There are many ways of saving energy and dollars on lighting, and many of them will yield fairly quick paybacks. The simplest and least expensive is simply to turn the lights off when they are not needed. This may be done manually or could be part of an overall automated building energy-management system. If there are not enough switches, it may be advisable to install more. An alternative would be to provide task lighting for very specific areas so that the general lighting can be turned off if not needed. Exterior lighting can be controlled by timers or photocells or a combination of the two. The photocell is a device that senses the presence of light; when darkness occurs it energizes the artificial lighting. In order to function properly the photocell must be clean. If it is dirty it may turn the lights on too soon.

If an area is too brightly lit, some lamps could be removed altogether. Another option is to remove one lamp from a two-lamp fluorescent fixture and to replace it with a "dummy" or "phantom" tube, which will draw no power but will allow the remaining lamp to operate. Simply removing one lamp from a two-lamp fixture will usually result in the remaining lamp not operating. It is also possible to replace standard 40-watt fluorescent lamps with "energy-efficient" lamps that draw about 32 to 35 watts.

The following examples from Sarnia and Kitchener show how quickly costs can be recovered by simply removing unnecessary lamps.

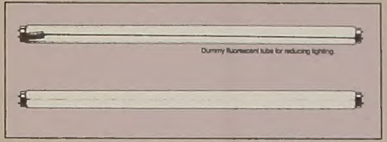
UTILITY PRACTISES WHAT IT PREACHES

As part of his duties, Don Van Goozen, Engineering Technician with Sarnia Hydro, was asked to seek out energy conservation possibilities in the utility's properties. One building that was known from the records to be an energy gobbler was the John T. Barnes Service Centre. Mr. Van Goozen had worked in the meter shop in that building for 20 years and had a good idea of what was contributing to the high energy use. The lighting in the meter shop was too bright. He did not make any measurements of the lighting, but a visual inspection revealed that much less light would still be adequate. The meter shop, approximately 93 square metres (1,000 square feet), is used primarily for calibrating and repairing meters. These work stations, however, take up only a small part of the total space; a large part of the floor is used for storage or is empty.

Originally the lighting consisted of 58 fluorescent fixtures evenly spaced around the ceiling. At a cost of approximately $680, one lamp in each of 45 fixtures was replaced with a dummy lamp.

Although the lighting load in the shop is not metered separately, the hours of use are known and the energy saving can be estimated. This value was calculated to be $530, which meant that the energy-conserving measure had a payback period of about 15 months.

Mr. Van Goozen reports that the results, from the standpoint of the occupants' visual comfort have been very satisfactory. In only a very few of the 45 fixtures has it been necessary to replace the dummy lamps with live lamps.



If an area is too brightly lit, "dummy" lamps can be used to lower light levels and energy use.

A SMART WAY TO USE DUMMIES

Officials of the Kitchener Library Board, who were concerned about the energy cost in their building, called upon Sharon McKinnon, Energy Auditor for the City of Kitchener for advice. An audit of the use of energy in the library included a measurement of the light level in the reading area. After comparing the existing light level with the accepted light levels of Ontario Hydro, it was decided that the reading area could do with much less light.

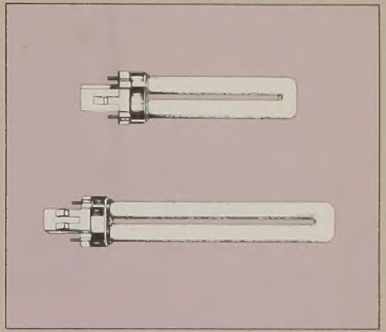
The lighting consisted of 600 two-lamp fluorescent fixtures. In about 40 per cent, or 250, of these fixtures one live lamp was replaced with a dummy lamp. In-house labour was used to make the change. The total cost of the alteration was approximately $3,225. The annual electrical bill for the library was about $37,450. The lighting portion was not known, but based on the hours of use and the wattage involved the saving from the dummy lamps was estimated to be $1,480. Additional money will be saved by having a lower cooling load since fewer lamps are burning. Although the saving is not large, compared to the total energy bill, it is an example of a measure that can yield a fairly rapid payback – in approximately two years.

Lynn Matthews, Chief Librarian, comments that "the new concept works extremely well. There has been no mention of the new lower lighting level from patrons using the reading area."

NEW DEVELOPMENTS

All fluorescent lamps (and also other types of gas-discharge lamps) require a ballast, a device that provides the lamps with the proper starting and operating electrical conditions. By their nature, ballasts have energy losses, usually in the order of 16 watts (for a 2-lamp 40 watt ballast). Newer types of ballasts are available, however, which have losses of about 6 watts. In addition, they last longer and also contribute to a reduced cooling load in the building. There is also a new, low-intensity ballast, which will reduce both light output from the lamps and electrical power input by about 30 per cent.

Another recent development is the "Compact Fluorescent" lamps, which are essentially small U-shaped or double U-shaped fluorescent lamps. They vary in length from about 4 inches (a 5-watt model) to 22 inches (a 36-watt model). They may be used to replace incandescent lamps. For example, a 10-watt compact fluorescent will produce the same amount of light as a 60-watt incandescent. Some are available complete with the ballast in an adapter base that will fit a standard incandescent socket. They have the advantages of high efficiency and long life (10,000 hours).



Highly efficient "compact" or "mini" fluorescent lamps can be used to replace inefficient incandescent lamps.

LITTLE LAMPS – BIG SAVINGS

The Queen Street Mental Health Centre consists of 16 buildings on a 27-acre site in west Toronto. The total area of the complex is 71,217 square metres (766,000 square feet). Hospitals are known as large users of energy and this facility is no exception. Carl Pierre, Director of Operations, is responsible for all energy-using systems with an annual energy expenditure approaching $1 million.

Energy conservation has been a priority for several years. It became obvious to Mr. Pierre that lighting offered potential for savings. Since much of the lighting is needed 24 hours a day, any reduction in lighting watts would yield not only demand savings but also considerable energy savings.

Discussions were held with representatives of a company that sells two products that seemed ideal when lighting is in use for many hours. The first of these is the "No-Watt Energy Saver", a device designed to limit the flow of current through a fluorescent lamp, thereby reducing the wattage. For example, one No-Watt Energy Saver installed on a two-lamp 40-watt fixture reduces the demand by 31 watts, and, for 24 hour-a-day operation would save 271.6 kilowatt hours per year.

The reduction in power input to the lamp is accompanied by a reduction in light output. In the case of the Queen Street project, the lighting level was not critical and the reduction was acceptable.

The second product is the PL lamp, a miniature fluorescent lamp that can be used to replace a standard incandescent lamp. In a typical retrofit a PL7 lamp might be used in place of a 40-watt incandescent lamp. The PL7 lamp, with a demand of only 10 watts (including ballast loss), yields a large reduction in demand. This is due to the much higher efficiency of the PL lamp. The lighting level would be slightly decreased.

The proposals were reviewed by lighting specialists from the Ontario Ministry of Government Services, who recommended that Mr. Pierre proceed with the changes. As a result, a total of 521 No-Watt units were installed in fluorescent fixtures in various parts of the complex, primarily in corridors and stairwells. The installed cost was $10,619. The annual energy saving was calculated to be $6,544, based on the 31-watt reduction per fixture and 24-hour-a-day use. This translates to a payback time of just under 20 months. A total of 656 incandescent lamps, each 75 watts, were replaced with PL7 lamps at a cost of $25,424. These lamps are in the community recreation centre, the cafeteria and some of the halls. With a calculated saving of $15,422 a year, the payback time is again just under 20 months.

Another benefit of the reduction in lighting is that less cooling is needed during the summer. In the case of the No-Watt units, the manufacturer claims that the decline in light output over the life of a fluorescent lamp will be reduced.

It should be noted that both these devices have relatively high capital costs. For that reason, a reasonable payback time is probably possible only when the lights are used for a large percentage of the time.

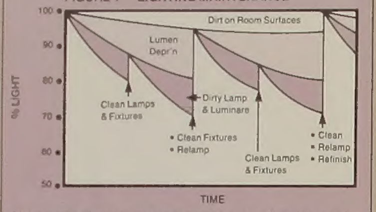
Mr. Pierre says that the new lighting has been very well accepted by all occupants of the buildings. In the case of the No-Watt units, there is no visible evidence that a change has been made.

656 incandescent lamps were replaced with high efficient mini-fluorescent lamps. The payback period is less than 2 years

CLEANING

The output of all lamps decreases with hours of use. This is known as lumen depreciation and cannot be avoided. However, it is possible to keep the light on the task as bright as possible by ensuring that lamps, fixtures and surroundings are kept clean. In fact, it may sometimes be possible to use fewer lamps if everything is kept clean.

FIGURE 1 LIGHTING MAINTENANCE



Dirt on room surfaces, plus lumen depreciation, plus dirt on lamps and fixtures contribute to light loss.

Source: Ontario Hydro, "Energy Management", 1981

HOW MUCH CAN BE SAVED?

The calculation of how much will be saved when a change is made to the lighting system need not be a complicated problem. However, since all the electricity used in the building (for lights, fans, pumps, water heaters, etc.) will usually be recorded on a single meter, it is not possible to segregate the lighting component. But by using the following method a fairly close approximation of the savings can be made.

First of all we need to know the rates charged by the electrical utility. If a rate schedule is not available a phone call to the utility will provide the necessary information. A typical rate schedule might look like this –

(a) Demand charges:
0 to 50 kW – No Charge
Over 50 kW – $3.17 per kW

(b) Energy charges:
First 250 kWh – 6.4¢ per kWh
Next 11,000 kWh – 4.77¢ per kWh
Remaining kWh – 3.36¢ per kWh

The above are monthly, net rates.

EXAMPLE:

1. Assume that before the lighting was changed, the total building demand was 300 kW and the energy was 56,000 kWh for a typical month.

   Assume that we have removed 40 kW of lighting load that was usually in use for 50 hours a month. This would have accounted for 2,000 kWh per month (40 kW × 50 hrs). The total demand will now be 300 kW – 40 kW = 260 kW, and the monthly energy will be 56,000 kWh – 2,000 kWh = 54,000 kWh.

The original monthly bill would be as follows:

50 kW	No charge
Next 250 kW @ $3.17 per kW	$ 792.50
First 250 kWh @ 6.4¢ per kWh	16.00
Next 11,000 kWh @ 4.77¢ per kWh	517.00
Remaining 44,750 kWh @ 3.36¢	1,503.60
Total bill	$2,829.10

The new bill would be as follows:

50 kW	No charge
Next 210 kW @ $3.17 per kW	$ 665.70
First 250 kWh @ 6.4¢ per kWh	16.00
Next 11,000 kWh @ 4.77¢	517.00
Remaining 42,750 kWh @ 3.36¢	1,463.40
Total bill	$2,635.10

Savings – $2,829.10 minus $2,635.10 = $194.00 per month

If the capital cost of the energy saving measure is known, say $3,200, the payback time will be

$$\frac{\$3{,}200}{\$194 \times 12 \text{ months}} = 1.37 \text{ years.}$$

Most of the lighting manufacturers have computer programs that will perform all these calculations.

FINAL COMMENTS

An important consideration that may be overlooked when altering lighting systems is the effect on the heating and cooling loads in the building. Usually all lighting energy ends up as heat somewhere in the building. If a redesigned lighting system results in considerably less wattage, it may be necessary to supply additional heat to a space from the heating plant. This of course reduces the overall saving slightly. On the other hand, there will be less demand for cooling in warm weather.

IN CONCLUSION

- The lighting systems in many buildings present a relatively simple opportunity to save energy and money.
- Payback periods are usually short to medium
- The efficiency of the light source should be considered.
- Colour rendition may be important.
- Overlighting is a common problem, but the light should be bright enough for the activity being undertaken.
- Good maintenance should be practised.
- Help is readily available from lighting manufacturers or local electrical utilities.

PROJECT SUMMARIES

Bond Park Baseball Diamond, North York
Cost of Project – $12,132
Estimated Annual Savings – $1,000
Payback Period – 12.1 years
(The change was primarily to increase the light level, not to save energy.)

Cummer Arena, North York
Cost of Project – $11,872
Estimated Annual Savings – $3,300
Payback Period – 3.6 years

Sarnia Hydro Meter Shop
Floor Area – 93 square metres (1,000 square feet)
Cost of Project – $680
Estimated Annual Savings – $530
Payback Period – 1.3 years

Kitchener Public Library
Cost of Project – $3,225
Estimated Annual Savings – $1,480
Payback – 2.2 years

Queen St. Mental Health Centre,
Ontario Ministry of Health
Total Floor Area (16 buildings) – 71,217 square metres (766,000 square feet)
Cost of Project – $36,043
Estimated Annual Savings – $21,966
Payback Period – 1.6 years

For further information contact:

Call (416) 965-6471
Outside Toronto,
Call the operator and ask for Zenith 80420

Ministry of Energy
Municipal and Commercial Programs
56 Wellesley Street West
10th Floor
Toronto, Ontario
M7A 2B7

12M/1477/4/87

Lighting:
Reducing Costs and Energy Use

With an annual energy expenditure approaching $1 million, energy conservation as a way of reducing costs has been a priority for several years at the Queen Street Mental Health Centre.

Ontario
Ministry of Energy
Vincent G. Kerrio
Minister